

United States Army School of Aviation Medicine
Fort Rucker, Alabama
MARCH 2003



LESSON PLAN

TITLE: THE VISUAL SYSTEM IN FLIGHT

FILE NUMBER: 20/7A/7C/9C/4L/41/84/67/55/33/3K/1J/98/48/5B/UEG-4520-1

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The Visual System in Flight
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Prerequisite Lesson(s)	<div><div><u>Lesson Number</u></div><div>None</div></div> <div><u>Lesson Title</u></div>																			
Clearance Access	Security Level: Unclassified Requirements: There are no clearance or access requirements for the lesson.																			
Foreign Disclosure Restrictions	FD5. This product/publication has been reviewed by the product developers in coordination with the USASAM foreign disclosure authority. This product is releasable to students from all requesting foreign countries without restrictions.																			
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Student Study Assignments	Study student handout and review reference materials listed above.																			
Terminal Learning Objective	<table><tr><td>Action:</td><td>Manage the effects of visual limitations during day flight.</td></tr><tr><td>Conditions:</td><td>While performing as an aircrew member.</td></tr><tr><td>Standards:</td><td>In accordance with (IAW) FM 3-04.301, Fundamentals of Aerospace Medicine, 3rd ed., AR 40-501, and AR 40-8.</td></tr></table>				Action:	Manage the effects of visual limitations during day flight.	Conditions:	While performing as an aircrew member.	Standards:	In accordance with (IAW) FM 3-04.301, Fundamentals of Aerospace Medicine, 3rd ed., AR 40-501, and AR 40-8.										
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Safety Requirements	None																			
Risk Assessment Level	Low																			
Environmental Considerations	NOTE: It is the responsibility of all soldiers and DA civilians to protect the environment from damage. None																			
Evaluation	On the last day of aviation medicine academics, each student will be evaluated on this block with a 50 question examination in which they must answer 35 of 50 questions correctly to receive a passing score. The test will be given in room X110 of Bldg 301.																			

A. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the components of the human eye and their functions.
CONDITIONS:	Given an list
STANDARDS:	IAW FM 3-04.301.

a. The cornea is the transparent protective tissue located over the front of the eye. It is almost circular in shape and projects forward. The degree of curvature varies with each individual.

b. The iris is the round pigmented (colored) membrane surrounding the pupil, having ciliary muscles that adjust the size of the pupil to regulate the amount of light entering the eye.

c. The pupil is the opening in the center of the iris (black center portion). It allows light to enter the eye. During daylight conditions the pupil constricts, during dark conditions the pupil dilates.

NOTE: Pupil size is inversely related to the amount of light presented. Increases in pupillary diameter decreases image sharpness in a less than perfect lens system (i.e., most eyes). Aviators who have mild refractive errors may not need to wear their glasses during day light viewing conditions when pupil size is small. However, at dusk or night, the pupil become larger causing vision to blur unless corrective glasses are worn. Aviators who have mild refractive errors in their lens system must wear properly fitted glasses for night operations.

d. The lens is a transparent, biconvex membrane located behind the pupil. The lens directs light rays entering the pupil upon the retina.

e. The retina is a thin multi-layered membrane which covers most of the posterior compartment of the eye. The retina contains the rod and cone cells of the eye. These cells permit us to see. The retina also contains a coloring tint called rhodopsin or visual purple which aids in the effectiveness of the rods during low light conditions. When exposed to sunlight, the retina cells become bleached resulting in a temporary decrease in night vision.

NOTE: The retina is a complex structure consisting of ten layers. One such layer, the Jacob's membrane, contains the photoreceptor cells, rods and cones, so named because of their shape. These photoreceptor cells translate light images into electrical pulses for transmission via neurons to the brain. Cones operate most efficiently at ordinary illumination levels which prevail throughout the day and in normally lighted rooms at night. When the illumination decreases to about the level of full moonlight, rods are most effective.

(1) Cone cells allow you to identify colors. They are utilized primarily during daylight hours or in other time periods when a bright light source is present.

(a) Seven million contained in the fovea and parafoveal regions of the retina.

(b) Sharp visual acuity and color sense due to 1:1 ratio of cone cells to neuron cells.

(2) Retinal blind spot.

(a) The day blind spot results from the existence and location of the optic disk within the retina. The optic disk is formed from where the optic nerve enters the retina. The optic disk contains no photoreceptor cells (cones and rods). The day blind spot covers an area of 5.5 to 7.5 degrees within your visual field and is located about 15 degrees from the fovea.

(b) Viewing with binocular vision compensates for the day blind spot. Each eye overlaps the other when viewing. The day blind spot is not normally noticed unless one eye is not being used for viewing.

B. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the common visual deficiencies.
CONDITIONS:	Given a list.
STANDARDS:	IAW FM 3-04.301 and AR 40-501.

- a. Astigmatism is caused by an unequal curvature of the cornea resulting in the inability of the eye to focus on multiple objects simultaneously in the horizontal and vertical planes (meridians).
- b. Myopia (nearsightedness) is a condition caused by a refractive error in the lens which focuses distant objects in front of the retinal plane.
- c. Hyperopia (farsightedness) is a condition caused by a refractive error in the lens which focuses near objects behind the retinal plane.
- d. Presbyopia occurs when the natural aging process affects the human eye causing the lens to harden and lose its elasticity resulting in the inability of the eye to focus on near objects.

C. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the disqualifying surgical procedures.
CONDITIONS:	Given a list.
STANDARDS:	IAW AR 40-501.

- a. Radial Keratotomy (RK) is an operation in which a series of incisions are made upon the cornea from its outer edge toward its center in a spoke like fashion. It is performed to flatten the cornea and thus to correct myopia. Glare sensitivity (sparkling affect throughout viewing field) and tissue scarring are the contributors to disqualification.
- b. Laser Iridotomy is a surgical procedure for the treatment of glaucoma. It is performed by an incision creating holes upon the iris to allow fluid to move (flow) to the back of the eye. This procedure creates an artificial pupil.
- c. Photo Refractive Keratectomy (PRK) is an experimental procedure to correct corneal refractive errors by use of a laser which has replaced the use of scalpels to correct for myopia. PRK is designed to ablate or reshape the central cornea. The affects of this procedure flattens the cornea which bends or refracts the light properly on the retina thus correcting the myopic deficiency. This procedure has not been approved by the FDA and like radial keratotomy, permanently disqualifies an individual from flight for Army aviation. Irregularity of the cornea surface causing astigmatism is the most common contributor to disqualification.
- d. Lasik or Keratomileusis is the carving or reshaping of the cornea. Surgeons use a laser to shave the anterior half of the cornea creating a flap. The flap is retracted back and reshaping of the inner side of the cornea is performed through the use of a laser causing the cornea to flatten. After reshaping has been completed the flap is replaced in its original position and sutured (sewn) back into place similar to a band-aid affect. The flatter cornea now bends or refracts the light properly on the retina. Unlike RK or PRK this technique can correct for severe

myopia and hyperopia conditions. The main adverse effect is irregularity of cornea surface causing astigmatism. Additionally if the individual who had this procedure performed was involved in an accident and the flap was to become unattached, then the result would be a permanent defect to the cornea and severe degraded visual acuity. This procedure permanently disqualifies the air crewmember from flight for Army aviation.

NOTE: There are numerous surgical procedures available to have performed to correct for visual deficiencies, not all can be listed. The procedures stated above are currently the most common. Currently according to AR 40-501 and AR 95-1 states that any and all lasik or PRK forms of corrective eye surgeries are disqualifying to Army air crewmembers. Air crewmembers must consult their Flight surgeons prior to having these procedures performed.

D. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the type of vision used during the day.
CONDITIONS:	Given a list.
STANDARDS:	IAW FM 3-04.301.

a. Photopic vision.

(1) During daylight or bright light time periods.

(2) Use of central vision or foveal vision (cones mostly) where vision and acuity is optimized.

(3) The best viewing time period for color sense and image sharpness (visual acuity up to 20/20 with corrective lens if needed).

b. Focal vision is viewing (focusing) straight forward or towards an object, terrain, or the horizon.

c. Peripheral vision is scanning (focusing or viewing) on the outer regions of an individuals field of view (opposite of center field of view).

E. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the cues of depth perception.
CONDITIONS:	Given a list.
STANDARDS:	IAW FM 3-04.301.

NOTE: The visual system is the most reliable of the senses, however, some illusions can result from a misinterpretation of what is seen. As visual information decreases, the probability of spatial disorientation increases. Reduced visual references may cause several visual illusions.

a. Binocular cues depend on the slightly different view each eye has of an object. Binocular perception is of value only when the object is close enough to make a perceptible difference in the viewing angle of both eyes. Distances are usually so great in the flight environment that these cues are of little value. These cues operate on more of a subconscious level than monocular cues do. Study and training will not greatly improve them.

b. Monocular cues are derived from experience and are subject to interpretation.

(1) Geometric perspective occurs when objects appear to have different shapes when viewed at varying distances and from different angles. These geometric perspectives can be remembered by using the acronym LAV.

(a) Linear perspective occurs when parallel lines tend to converge as distance from observer increases.

(b) Apparent foreshortening occurs when viewing from a distance, the shape of an object appears elliptical (narrow), but as distance is decreased the true shape is revealed.

(c) Vertical position in the field occurs when objects or terrain features that are farther away appear higher on the horizon than those that are closer to the observer.

(2) Retinal image size occurs when an image is focused upon the retina and is perceived by the brain to be of a given size. These retinal image cues can be remembered by using the acronym KITO.

(a) Known size of objects occurs when the closer an object is to an observer, the larger its retinal image. Through experience, the brain learns to estimate the distance of familiar objects by the size of its retinal image.

(b) The increasing or decreasing size of objects is used to judge whether an object is moving towards or away from an observer by its increasing or decreasing retinal image size.

(c) Terrestrial association is the comparison of one object with another object of known size to help determine the relative size and apparent distance of the object from the observer.

(d) Overlapping contours or interposition of objects is when objects overlap and the overlapped object is farther away.

(3) Aerial perspective is when distant information can be gained by the clarity of an object or by the shadow that is cast by an object.

(a) Fading colors or shades occurs when objects viewed through haze, smoke, or fog are seen less distinctly and appear to be at greater distance than they actually are. If atmospheric transmission of light is unrestricted, an object is seen more distinctly and appears to be closer than it actually is.

(b) Sharpness and clarity of details or texture is lost or is less apparent with distance.

(4) Motion parallax (one of the most important cues to depth perception) is the apparent, relative motion of stationary objects as viewed by a moving observer. Near objects appear to move past or opposite the landscape. Far objects seem to move in the direction of motion or remain fixed. The rate of apparent movement depends on the distance the observer is from the object. Rapidly moving objects are judged to be near while slow moving objects are judged to be distant.

F. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the methods to protect visual acuity from flight hazards.
CONDITIONS:	Given a list.
STANDARDS:	IAW FM 3-04.301.

a. Glare from direct, reflected, or scattered sunlight causes discomfort, reduction in visual acuity. To reduce or eliminate the discomfort, every aviator should wear their issued sunglasses and lower their tinted visor as necessary during day flight. Day blindness can occur in areas of extreme solar glare (snow, desert, and water environments).

b. Bird strike hazards may always be present both day or night at lower levels of flight. Cockpit windshields should be able to withstand a bird strike, but the potential exists for shattering of the windshield. Further protection is necessary by lowering your clear or tinted visors at the beginning of the flight that way if this hazard should occur, your eyes will be protected from the objects penetrating the windshield to include glass fragments.

c. Lasers produce light that is amplified by a stimulated emission of radiation through one or a series of multiple prisms. The beam of light produced is usually less than one inch in diameter.

NOTES: Lasers injury is primarily associated with your eyes, and from a considerable distance. Distance is the best protection, but if that is not possible the use of laser specific protective goggles and visors will provide protection. During your pre-mission planning you should attempt to identify what type or types of lasers at what locations and time you may possibly be exposed to during your flight. Identifying the specific type of laser will assist you in obtaining the correct laser protective goggle or visor that's required prior to your flight.

CAUTION: To date there are no protective goggles or visors that will independently protect you from all the different varieties of lasers.

(1) Some laser sources produce the beam of light in the visible portion of the radiation spectrum and can be seen. Others produce the light outside the visible spectrum (infrared or ultraviolet) and are invisible.

(a) Over long distances, the beam progressively becomes wider reducing its energy (strength or intensity).

(b) Some laser devices have sufficient energy to severely injure and burn the eyes or skin.

1. Range finders.

2. Target designators.

(c) Some military lasers produce a beam that is 1 meter in diameter at 1 kilometer and 2 meters in diameter at 2 kilometers.

1. At these distances lasers can irradiate the whole body.

2. If the energy, intensity of the laser is high enough, it can burn clothing, skin, or any part of the body exposed to it. However, most lasers are not powerful enough to generate burns.

(2) Sensitivity of the eyes related to lasers.

- (a) The lens focuses and concentrates (refracts) light that enters the eye upon the retina. Because of this the lens itself is very sensitive to injury from any type of laser.
- (b) The concentration of energy which is focused (refracted) from the lens to the back of the eye (the retina) can be increased 100,000 times greater than the energy entering the eye.
- (c) The amount of injury or damage to the eye depends on the type of laser, the laser energy output, duration of time exposed, and the distance between yourself and the laser.

(3) Types of possible burn injuries associated with lasers.

- (a) Tiny lesions on the back of the eye (retinal layers).
- (b) Severe burns effecting vast body portions.
- (c) Flash blindness.
- (d) Impaired night vision.

(4) Protective measures used to prevent laser injuries.

- (a) Passive measures consist of taking cover, getting out of the laser beam, and use any protective gear that is available associated towards lasers. Use of protective goggles B-LPS (Ballistic and Laser Protective Eyewear).

NOTE: The correct B-LPS must be used for each specific type of laser. Current protective eyewear are designed to protect against specific type laser frequencies; therefore, the use of issued protective eyewear does not preclude injury to the eye from other types of threat lasers not covered by the B-LP worn.

- (b) Active protective measures consist of the following.

- 1. Countermeasures taught or directed by your commander or leader.
 - 2. Maneuvers.
 - a. Applying evasive action.
 - b. Scanning the battlefield with one eye or monocular optics.

d. Nerve agent exposures are possible during times of conflict and peace.

- (1) How timely you identify the physiological effects of nerve agents during night operations may determined the success and survivability of your crew and its mission.

- (a) When direct contact occurs, minute amounts may cause miosis, constriction of the pupils. Pupils will not dilate (enlarge) in low ambient light as they would normally. Chemical alarms may not detect presence of nerve agents.
- (b) Exposure time required to cause miosis depends on the agent concentration and the cumulative effects of repeated exposure.

(c) Symptoms range from minimal to severe depending on agent's concentration and duration of exposure.

1. Severe miosis may persist for 48 hours or longer after onset of exposure.

2. Complete recovery may take up to 20 days or longer.

(2) There will be some loss of night vision among personnel exposed. Refer all exposed personnel to the flight surgeon immediately before performing flight duties or aircraft maintenance.

G. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the effects of the self-imposed stresses.
CONDITIONS:	Given a list of self-imposed stresses and their effects
STANDARDS:	IAW FM 3-04.301 and AR 40-8.

a. Drugs.

(1) Illness, degradation in motor skills, awareness level, and reaction time are all possible contributing side effects related to drugs.

(2) Refer to AR 40-8 for restrictions for drug use while on flying status. Self-medicating is not authorized, consult a flight surgeon for approval of drug use (medications).

b. Exhaustion.

(1) Poor physical condition and exercise, lack of rest, and inadequate sleeping patterns or habits are all contributing factors leading to exhaustion.

(2) Common side effects related to exhaustion are altered concentration, awareness, attentiveness, and increased drowsiness.

c. Alcohol.

(1) Histotoxic hypoxia is the poisoning of the blood stream causing interference with the use of oxygen by body tissues (decreased tissue perfusion).

(2) Long lasting physiological effects related to the consumption of alcohol. Detrimental effects related to the consumption of alcohol include poor or altered abilities upon judgement, decision making, perception, reaction time, and coordination.

(3) One ounce of alcohol will place you at 2,000 feet physiologically.

NOTE: Remember the guidance for performing aircrew member duties when consumption of alcohol is involved, is 12 or more hours or no residual physiological effects present from alcohol before resuming or performing crew member duties. This means that it may take you longer than 12 hours to recover from the effects in order to perform your crew member duties (Refer to AR 40-8).

d. Tobacco.

(1) Hypemic or anemic hypoxia is caused by the reduction of the oxygen carrying capacity of the blood (via the red blood cells- RBCs). It is in direct relation to the carbon monoxide binding with the hemoglobin, not allowing or severely decreasing the amount of oxygen binding with the hemoglobin as it should normally (vascular perfusion exchange of gases).

(2) Carbon monoxide has an affinity for hemoglobin 200-300 times greater than oxygen.

CAUTION: An individual smokes 3 cigarettes in rapid succession or 20 to 30 cigarettes within a 24 hour period, the carbon monoxide content of the blood is raised 8 to 10 percent. The physiological effect at ground level is the same as flying at 5,000 feet. Even more importantly, the smoker has lost approximately 20 percent of the night vision capability at sea level.

(3) The effects of smoking (hypemic hypoxia) places you physiologically at 5,000 feet.

e. Hypoglycemia and nutritional deficiency.

(1) Effects of hypoglycemia and nutritional deficiency results in hunger pains, distractions, breakdown in habit patterns, and shortened attention span.

(2) Contributing factors leading to low blood sugar (Hypoglycemia) and nutritional deficiency occurs skipping, missing, or postponing meals.